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ABSTRACT

Academic education should be integrated into vocational training in order to make both types of education more useful to students and more readily learned. College-level physics can be integrated into an automotive technology curriculum and students taught with a much more hands-on approach than has traditionally been taken. One such program is being conducted at Waukesha County Technical College in Wisconsin. The Automotive Service Educational Program is associated with General Motors (GM) and was collectively developed by physics instructors, automotive instructors, college administrators, and GM personnel. The structure of the program includes 9-week increments of on-campus course work, 8 hours per day, followed by 9 weeks of in-dealership work experience. This sequence is followed for 2 years for an associate degree. The course work follows the Unified Technical Concepts curriculum as prepared by the Center for Occupational Research and Development (CORD). During the in-dealership time, college teachers of both automotive and physics courses visit the students at work. GM donates vehicles to the school to be used in the college course work. Regular advisory committee meetings of college and GM personnel are held. The program provides real-world experience for students and a better forum for learning abstract subjects. (KC)

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FIRST SOVIET-AMERICAN SYMPOSIUM

Modern Teaching/Learning Technologies

in

Professional Education

Strategies to Facilitate Change in Higher Education

example

Physics in the Automotive Curriculum

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September 13, 1990

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TOPICS PRESENTED

A. THE CASE FOR INTEGRATING GENERAL EDUCATION INTO OCCUPATIONAL PROGRAM CURRICULUMS.

B. THE AUTOMOTIVE SERVICE EDUCATIONAL PROGRAM (ASEP) AND ITS CHARACTERISTICS AT WAUKESHA COUNTY TECHNICAL COLLEGE.

C. THE COURSE: UNIFIED TECHNICAL CONCEPTS (UTC) AS PREPARED BY THE CENTER FOR OCCUPATIONAL RESEARCH AND DEVELOPMENT (CORD).

D. THE TEACHING EXPERIENCE.

E. THE STRATEGY FOR MOVING FORWARD

The teaching experience is shaped by many factors that operate independently as well as collectively in the classroom setting. The experience of this physics teacher of 25 years is that the organization of the curriculum into the fewest number of integrating concepts with the maximum amount of hands on exposure to diverse applications of those few concepts is the recipe for both a good learning and teaching experience.

To arrive at the "good" experience, the academic teacher, physics in this case, has to work with diligence and purpose to pass on the clear message that the physics course is purposefully integrated with the associated occupational program and its content, in this case, the automotive program. That is to say that we, the academic teachers in a vocational-technical environment, must explore and discover those technician encountered processes, situations and problems imbedded in the occupational activities that are best understood in terms of fundamental physics concepts. We then will best serve our students by organizing the academic, physics, content into few, unified concepts that the student will be able to carry away with him/her.

Building on the framework of theoretical models, there are obviously many more legitimate topics than there is time available in a single, two , or three-term course. In such a situation, it is clear that one important filter is to ask the question, "Can this topic be presented in a way that the student can use the strength of physics-the capacity to build flexibly and confidently on previous knowledge?" <u>If we cannot help a student hang the new material on some previous framework of concept, knowledge, or analysis, then its value is</u>

questionable.[1] (Emphasis added)

It is widely accepted that change is necessary in most of the current techniques involving introductory teaching of physics. In addition to the need to be able to present physics content within the framework of a manageable number of unifying concepts, there are recommendations to support the appropriate hands-on activities usually referred to as laboratories.

RECOMMENDATION #4

The NSF (National Science Foundation) staff establish programs to support curriculum revision of introductory courses in science, mathematics and engineering; to develop improved laboratory and demonstration equipment; and to develop new introductory laboratory experiments of a concrete, hands-on style to complement other course activities.[2] (Emphasis added)

Additional affirmation of the need for review of much of the current practice of separation of the occupational and general education curriculums is the following call for reform.

It is appropriate and necessary, therefore, that vocational education systematically and creatively integrate academic and technical skills.[3]

Willing to accept the need to do the business of vocational-technical education differently, let me share some of the characteristics of the automotive curriculum at Waukesha County Technical College. The Automotive Service Educational Program (ASEP) is a cooperative curriculum that has very highly structured ties to the private sector; in

this case, General Motors Corporation and General Motors Dealers within the state of Wisconsin. Our association with the Corporation initiated with GM Corporate personnel, WCTC administration, automotive instructors and related instructors, including physics, sitting down and collectively developing a program structure and a curriculum sequence. The general feature of the structure include:

- All educational activities for the students are organized in 9 week increments
- 9 weeks of on-campus coursework, 8 hours/day, are followed by 9 weeks of in-dealership work experience. This sequence is followed for two years for completion of the associate degree.
- The "physics" course, Unified Technical Concepts (UTC), is in the 2nd 9 week on-campus increment.
- college teachers (automotive and physics) visit the students at the dealership during the students 9 week in-dealership work experience.
- GM donates 10 to 12 vehicles per year to the school to be used in the colleges coursework. In addition there is mutual agreement that no vehicles used for coursework will be older that 3 years.
- regular advisory committee meetings including dealership representatives, former students and WCTC personnel.

I have found that teaching in the ASEP program is uniquely rewarding in comparison to much of teaching that I do in other programs. The close association with the private sector in this program gives educators a measure of "real world" feed-back that isn't available in some other programs. For example, it is the access to service and support manuals

that allows me to discover that the accelerometer topic (Transducer Concept) in my text is exemplified in the auto as its knock sensor. This kind of information can be the difference between having the student recognize that the concept under discussion is important to him/her or not.

The "physics" course of the ASEP curriculum is a departure from a traditional introductory physics course.

> UTC (Unified Technical Concepts) is an alternate method of presenting what has been a formidable, and sometimes confusing, subject for technicians. It provides laboratory experiments that apply to specific technological fields, allowing students to relate more quickly to module content.[4]

The overriding difference in UTC, and primary emphasis of the course, is the focus on 13 unifying concepts to convey the content of technician appropriate physics. These thirteen concepts are applied to each of the four primary energy systems; mechanical, fluidal, electrical and thermal. A second defining attribute of UTC is the heavy reliance on analogies. That is to say that students are asked to think of the similar behaviors between energy systems. As an example of this Concept-Analogy based curriculum, Chapter 1 of UTC is the concept of FORCE . That by itself is unremarkable until you find that the concept FORCE also means physically similar quantities of the other energy systems! In this first chapter of the text students will be discussing and experimenting with force and force-like (by analogy) quantities. Looking at the following listing will most readily illustrate the structural organization of the FORCE concept

(Chapter 1).

FORCE AND FORCE-LIKE QUANTITIES AGENTS OF CHANGE			
ENERGY SYSTEM	FORCE-LIKE QUANTITY	UNITS	QUANTITY AFFECTED
Mechanical Translational Rotational	 Force Torque	 Newton N-m	 Mass moved Mass rotated
Fluidal	Pressure difference	Pascals	Fluid volume/mass moved
Electrical	Potential difference	Volts	Electrical charge moved
Thermal	Temperature difference	C^o	Heat energy moved

In summary of the FORCE Concept, CORD says:

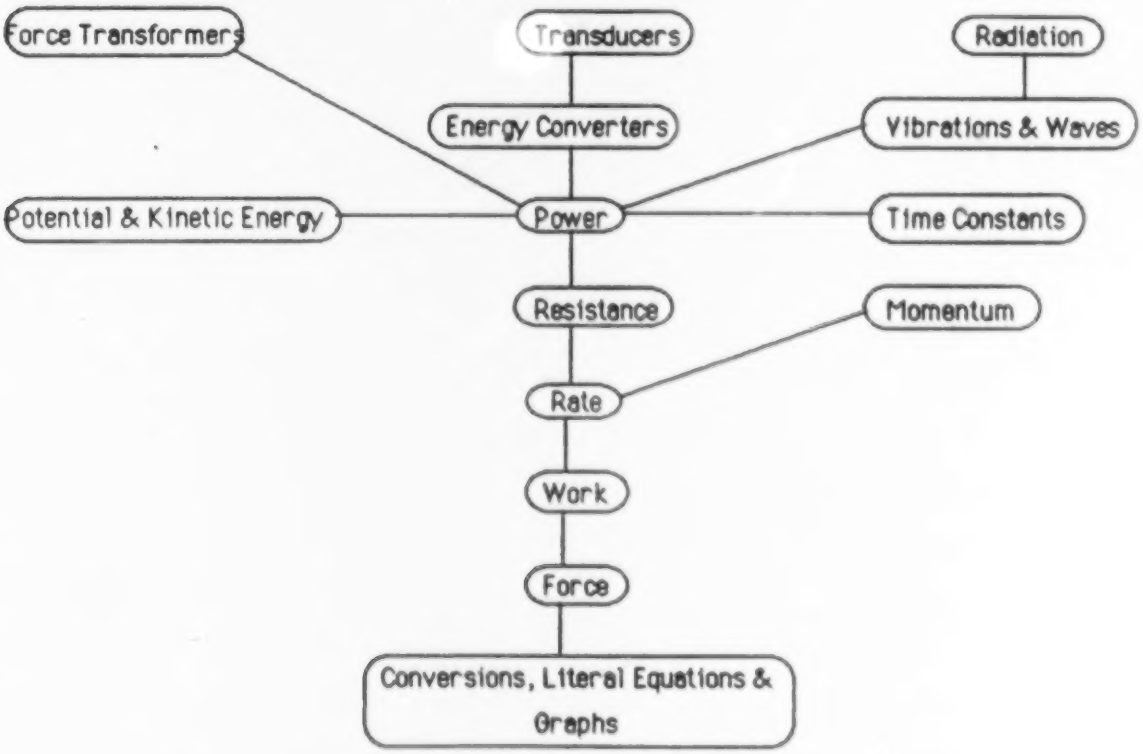
> Force-like quantities are the prime movers in all physical systems. Although one would be incorrect to say that net force, net torque, pressure differential, voltage, magnetomotive force and temperature difference affect their energy systems in exactly the same way, they play strikingly analogous roles. The basic and very important similarities of these physical quantities can be of value in applying knowledge gained in one energy system to the solution of problems in other energy systems.[5]

In addition to the emphasis on concepts and analogies CORD has prepared for the UTC curriculum a set of laboratory experiments (application modules) from which the physics instructor can select according to the

criteria of concept and energy system. Since there are 13 concepts and 4 energy systems, complete coverage would be provided by 52 application modules. In fact there are 170 application modules providing for instructor choice on any given concept-energy system topic.

The UTC course that is taught at WCTC draws from the 13 concepts according to the following flow chart.

CONCEPT FLOW CHART:



Our course selects the 8 concepts from UTC and adds an introductory review of conversions, literal equation manipulation, and reading of graphs. Here is evidence of our effort to put academic topics in every-day circumstances by using data from motorcycle magazines as the basis of the conversions and graph readings.

The effort to make the physics experience relevant was paramount in our minds as we planned the UTC application modules. One criteria we used was to base as much as possible of our laboratory activities on automotive devices and equipment. If we needed an electric motor, we use an automotive blower motor or power window motor. If we need a fluid pump we use a fuel pump or a windshield washing pump. If we need a heat exchanger, we use an auxiliary rear heater unit from a van or an auxiliary engine oil cooler. The point is that the students will see that the physics concept under discussion/investigation is exemplified in the kinds of devices on which they work. The students will see that their world of work is a subset of the unified physics concepts of UTC. In terms of preparing the laboratory, we did not purchase any equipment from educational supply houses. Instead we bought from automotive and industrial supply companies. As an example, you will not see any "panel" electrical meters, but rather Fluke multimeters, the same s used by the practicing GM automotive service employees. You will not see any thermometers in the laboratory - all temperatures and measured by thermocouple based sensors that attach to the Fluke meter.

These changes involve the physics teacher to be close enough to his occupational counterpart so that advice on instruments and devices to be used in the laboratory represent the current industry practices. The pay off is that the students see the relevancy of a related academic course. This acknowledged relevance by the student translates to acceptance by the students and generally good teaching experience.

The UTC based course at WCTC lasts 9 weeks with the students meeting 12 hours/week. Of the 12 hours/week about half is spent in lecture/discussion and half in laboratory work. Since we spend one week

per concept, we are able to do from two to four laboratories per concept. Seeing more than one laboratory example from each concept is important in that the student will see that the concept apply equally will in different energy systems. Problems are assigned as part of both the lecture and laboratory part of the course.

The experience of teaching the UTC course in our attempt to tightly integrate with occupational content includes the following impacts on me.

- Must allocate time differently - I now make regular contacts with both the occupational staff and the students in the dealership.
- Had to acquire a new mindset about the laboratory - not just a repetition of the labs I had done as an undergraduate - but now new device based laboratories that illustrate an integrated concept with tools/instruments that are common the industry.
- The course is more dynamic than traditionally taught physics because the search for current devices/instruments continues as changes occur in the technology.
- The intensive time frame (12 hr./week for 9 weeks) is better for keeping students "focused" on the current and past concepts.
- Different relationships with occupational teachers during curriculum development. I no longer say "Accept these two semesters of physics because that is what physics includes." I now have a responsibility to defend the integrity of the necessary learning sequence of concepts in the light of the concepts deemed appropriate by the occupational instructor.

An important step in the implementation of UTC is to identify the technology programs to be served. Once these are determined,

the physics instructor needs to consult with key instructors in the technology areas to select the appropriate modules for their students. Since the technology instructors probably lack familiarity with UTC, the physics instructor should be prepared to recommend specific concept and application modules to meet their needs.

Once the appropriate concept and application modules have been identified, it is necessary that the physics instructor and the instructors of the separate technologies examine the curriculum plan together. Cooperation in this matter will help the physics instructor maximize the benefit of UTC by arranging the modules in a proper sequence to best support the technology programs. For example, to provide a lead-in physics support for an electronics technology program it would be advantageous to present Concept Module 11-0, 'Vibrations and Waves,' before the basic course in ac electronics is taught. It is important to recognize that both the selection and sequencing of UTC modules is influenced and constrained by the subject matter needs and curriculum construction of the technology programs.[6]

We have found that once the initial "caution" by the occupational instructor toward UTC is over and the occupational instructors realize that the physics course can and is making his work easier, they will initiate topics/devices that should be included/expanded upon for the benefit of the student in subsequent occupational courses. In other words, we have gained the confidence of the occupational staff - we are in the same camp instead of viewing each other with customary suspicion.

I recognize that one persons experiences of teaching physics does not form the basis for a rational strategy of change. However, when the frustrations (common also to his peers) of one persons experience in teaching physics traditionally, can be changed by a different approach to the same content, then I believe we should investigate in a systematic way how these improvements can be generalized. I am here in the role of a classroom teacher of physics and based solely on my experience I recommend the following:

- More curriculum development efforts such as UTC by CORD - Extensive, scientifically based on-going efforts are needed to creatively focus on <u>few unifying concepts</u> to serve as a framework for the subject matter content.
- Concepts coupled with technology appropriate activities that document the concept and its use in seemingly unrelated areas.

The fact that students show context dependence in the application of concepts to situations that physicists would consider analogous suggests that we need to diversify the students experiential base, as well as to teach them a structure for organizing it. The type of thinking that proceeds from governing principles rather than surface features requires, in part, the ability to recognize when a principle is applicable, that is, to have a sense of its range of applicability. Organization becomes valuable only when there is enough stored in the students memory to make it efficient to organize the knowledge (i.e. you can't meaningfully order a deck of only two cards). We believe that most good teachers know how to help students expand and structure their knowledge base,. When teaching a concept, good

teachers help students explore the ramifications of the concept through a diversity of examples that explore the range of the concept's applicability.[7]

This view was also voiced in Senate Testimony by Dr. Charles Benson when he said:

> Cognitive scientists have studied process by means of which people acquire both academic and job specific skills...In general, 'learning by doing' is an effective instructional strategy over a wider span of the measured ability spectrum than is traditional academic instruction, based on lecture and text. Also, teaching theory in a practical context appears to offer much transferability from the study of instructional modules to the solving of problems in the work place.[8]

- Institutionally initiated attempts to break down the barriers between academic and occupational staff. (The degree of success will hinge in part on the availability of credible curriculum efforts such as done by CORD.) Have related academic instructors, in groups of two or three, have offices with their occupational counterparts. The likely-hood of them discovering the existence of an educational need, from the occupational standpoint, and an educational ability, from the academic side; is greater if they interact more often. I recognize that this will most likely resisted by both groups and if initiated will cause a period of uncomfortableness. I think that the potential gain is worth the associated problems.

1. Holcomb, Donald F. *Introductory Physics - Searching for a New Paradigm* The Physics Teacher February 1987 pp 76

2. *Report on the National Science Foundation Workshop on Science, Engineering, and Mathematics Education in Two-Year Colleges* Directorate For Science and Engineering Education: National Science Foundation June 1989 pp 4

3. Kraska, Marie *Insider- Technical Education Division* Vocational Education Journal September 1990 pp 41

4. CORD Unified Technical Concepts - Instructors Guide CORD Preface

5. CORD Physics for Technicians - A Systems Approach John Wiley & Sons 1988 pp 80

6. CORD Unified Technical Concepts - Instructors Guide CORD pp11

7. Jose Mestre & Jereold Touger *Cognitive Research - What's in It for Physics Teachers* The Physics Teacher September 89 pp 455

8. Charles Benson, Testimony of: *Integrating Academic and Vocational Education* The Senate Subcommittee on Education, Arts, and Humanities July 27, 1989 pp 8